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1.0 Aerosol Retrieval Over Land

a. Algorithm Development

The coded algorithm was tested with four TM images reduced to MODIS resolution size. The results of this test is under analysis.

b. Aerosol Models

During the past half year we have continued to refine the sulfate and smoke aerosol models. The sulfate model consists of five lognormals of fixed radius and standard deviation which vary in volume according to the aerosol optical thickness. Two of the modes represent the aerosols resulting from gas-to-particle conversion and cloud processes, respectively. Most of the optics in the model are determined by the relative strengths of these two modes as the aerosol optical thickness changes. The smoke model consists of two lognormals of fixed radius and a coarse mode of varying radius. The optics of the smoke model are also dominated by the accumulation mode. The differences between the two regimes result from the fact that the particles in the sulfate accumulation mode grow in size as optical thickness increases while the smoke particles do not. This implies that increasing optical thickness in the sulfate regime is caused not only by increasing the aerosol loading but also by increasing the optical effectiveness of the particles, whereas the increase in optical thickness in the smoke is due solely to the increase in the number of particles. These differences have important repurcusions on aerosol-cloud interactions, remote sensing of aerosol from space and the direct/indirect effect of aerosol on climate change. Our findings were summarized in a paper that was submitted to the volume of bound papers presented at the Chapman conference on Biomass Burning.

As part of our work on aerosol modeling we discovered a flaw in the inversion algorithim which calculates aerosol volume distribuiton from sky radiances. At both the smallest and largest radii the inversion overcompensates for boundary conditions which force the distribution to be zero beyond the resolved range of particle sizes. This creates an appearance of an abundance of unphysically small and large particles. However, this is a minor flaw in that the inversion retrieves a size distribution which accurately reflects the correct optical properties of the aerosol even though the size distribution itself is in error. To correct the inversion flaw we match the single-scattering radiance calculated from the flawed volume size distribution for the first 40 degrees to that of a lognormal distribution in a look-up table. The reasoning is that the inversion must gives us the correct optics for the first 40 degrees. We then correct the volume of the distribution by keeping constant the optical thickness before and after the adjustment. The result of the correction is a physically realistic volume size distribution with the same optics as measured by the instrument. We tested this model by comparing model-generated sky radiances to those measured directly by the sun/sky radiometers and we get excellent agreement.

The modal radii suggested by our models for the accumulation and coarse modes agree well with previous ground-based in situ observations. However, the standard deviations or modal widths of our model tend to be larger than previously observed. Our models stratospheric modes also agree with different measurements of stratospheric aerosol measured in the post-Pinatubo period. We compared our SCAR-A volume size distribution retrievals to airborne in situ measurements of the Univ. of Washington C131A aircraft. Qualitatively the comparisons look very promising. The two data sets both show the major modes in the appropriate size ranges on both hazy days and clear days, when salt is present and when it is not. Furthermore, the in situ data show the same dependence of accumulation mode size on optical thickness although the in situ measured modal widths are narrower and the volume-weighted radii of the accumulation modes are smaller than those measured by the cimel instruments. There is uncertainty in the aircraft measurements as well as the remote sensing instruments so that neither data type is a validation of the other, but the overall agreement of the two measurement methods is an encouraging sign for both, and for the aerosol models derived from the data sets.

2.0 Planning for SCAR-B

We progressed quickly in planning SCAR-B during the first half of 1995. The following are some important milestones to which we have contributed:

- Completion of the SCAR-B Mission Plan. This document describes the scientific objectives and a broad plan outlining how these objectives will be met by the integration of the three different aircrafts, ground researchers, satellite analyses and sun/sky radiometer network. Also included in this document is a detailed description of the logistics involved.
- Completion of the SCAR-B Detailed Plan. This document describes four specific scenarios: 1) cloud free mixed aerosol 2) aerosol-cloud interaction 3) individual fires 4) large scale variability of aerosol. In each scenario, the roles of each research group is outlined and the necessary measurements and analysis specified.
- Joint US-Brazilian planning meeting at Williamsburg VA. At this meeting, the continuing diplomatic difficulties were discussed (since resolved) and preliminary plans were introduced and discussed. In subsequent informal discussions in the days following the formal meeting outstanding issues were identified, some resolved and some left as action items.

- Preparation of the Aircraft Operations Map. A map indicated the limits of the aircraft operations in Brazil and coastal ocean was delivered to headquarters. The aircraft operations area was divided into 5 sectors corresponding to different scientific objectives such that we may comply with the Brazilian airforce request to announce in advance in what sector will we fly on any particular day.
- Inclusion of AVIRIS. Permission and funding was sought and secured to bring AVIRIS to Brazil. AVIRIS provides an important additional data collection ability.
- Signing of the MOU between Brazil and the U.S.
- Implementation of the SCAR-B Internet World Wide Web page which offers on line GOES imagery loops, Univ of Wisconsin fire product and custom meteorological information.
- Joint US-Brazilian planning meeting in Brasilia Brazil in June. At this meeting the details concerning flight plans, meteorological forecasting, Brazilian Air Force restrictions, schedule of events, fires-of-opportunity, surface sites, collaboration with IBAMA, logistics, etc were discussed and issues resolved. Data acquistion was tested at IBAMA and found to be useable.
- Revision of flight planning/notification operations. Flight region limited in area from original Aircraft Operations Map. Original sectors replaced by 24 hour notification of flexibly defined research areas.
- Identification of the SCAR-B meteorologist and mission operations site (IBAMA). Claudine from INPE CPTEC will be the meteorologist and she is preparing to access CPTEC meteorological products and the SCAR-B Web page for daily forecasts. The operations site will be at IBAMA where the facilities include excellent computer work stations, telephones, maps and scientists eager to collaborate.
- Coordination with Glenn Shaw and Ji Qiang of the Univ of Alaska, Fairbanks, to have a surface-based CCN counter(s) available in Cuiaba and other cities during SCAR-B.
- Coordination with Joseph Vaughan of Washington State University to have a shadowband radiometer available in Brasilia and later moved to Cuiaba.

3.0 SCAR-C Data Analysis

3.1 MAS calibration

There are three separate calibrations being performed on the SCAR-C MAS data, the visible channels, the thermal channels at background temperatures and the thermal channels at high fire temperatures. To calibrate the visible channels NASA/Ames personnel used the NASA/Ames integrating sphere characterized by John Cooper of NASA/GSFC. The resulting visble channel calibration was used in an intercomparison with AVIRIS flying on the same mission. The results of the intercomparison show that MAS agrees with AVIRIS in calibration slope but that there are offsets between the two instruments. The offset is insignificant at 0.55 µm, but as much as 0.05 in reflectance units at 0.87 µm. A second intercomparison from the same flight but several hours later which also included some scenes of clear ocean also show offsets between the two instruments in some channels. Reflectance of ocean targets in AVIRIS are less than 0.005 for 1.64 µm while reflectance for MAS in this channel for the same targets are -0.02. Ocean targets at 0.87 µm for AVIRIS have 0.02 reflectance while for MAS the reflectance is 0.06. The AVIRIS results over the ocean targets are much closer to physical expectations than MAS . This is due to the more rigorus calibration procedures for AVIRIS and because AVIRIS is thermally controlled in flight while MAS is not. In all future analysis of SCAR-C data we intend to adjust the MAS data to AVIRIS values.

The background temperature calibration is proceeding well by using the onboard calibration procedure. We have retrieved some useful results. However, there are still some problems with the 3.9µm channels. Also high temperature calibration is disappointing. Initially we had hoped to calibrate for fire temperatures by using a hotplate technique developed by Jim Brass at NASA/Ames. Unfortunately this techniqure produced unusable results. We are trying to extrapolate the onboard calibration procedure to the higher temperatures but are uncertain of our accuracy.

Calibration is still in progress, although we are pessimistic about ever retrieving fire temperature from the thermal channels and will have to rely on the 1.64µm channel for quantitative fire information.

3.2 Fire Analysis

We have analyzed the Quinault fire which is a prescribed fire that sent a well-defined smoke plume over the ocean. There are eight ER-2 observations of this fire over a two hour period. We have related the size of the fire to the amount of smoke by plotting both quantities as a function of time. We also have related the emitted thermal energy to the smoke and compared both to similar quantities predicted by the USFS models. Our results show clearly the relationship between fire thermal energy and fire emissions and how these quantites can be monitored by remote sensing. In doing this analysis we have modeled the fire thermal energy as a function of wavelength and pixel size and have found that for MAS-size pixels, the 1.64 µm channel is as sensitive to the fire as the 3.9µm channel is for MODIS-size pixels. All quantitative analysis of the Quinault fire thermal energy was done using the better-calibrated 1.64 µm channel. Our results were summarized in a paper submitted to the volume of the Chapman conference on Biomass Burning. Currently we are repeating this analysis for other prescribed fires from the same SCAR-C flight line. Eventually we will integrate our findings with those measured in situ by the Univ. of Washington's C-131A aircraft.

4.0 Attendance Chapman Conference

Yoram Kaufman and Lorraine Remer attended and presented papers at the Chapman Conference on Biomass Burning in Williamsburg VA in March. The time there was also spent attending a SCAR-B planning meeting and an informal SCAR-C data analysis workshop. These formal meetings plus the informal discussions with many collaborators were important and acted to advance both the SCAR-B planning and organize the SCAR-C analysis.